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ABSTRACT

Research has not clearly determined whether memory development in childhood and adulthood can be accounted for by the age variation of cognitive processes other than memory. To examine this issue, a study was conducted based on a model of structures and processes in complex information processing. Subjects (N=162) were presented with two lists of learning material, one with meaningful material and the other with meaningless material. Lists were presented acoustically and visually. Subjects were asked for recall; recall rates were used as dependent measures. Problem-solving was measured by ordered concept-forming tasks involving prediction. Subjects were from seven age groups (8, 10, 12, 15, 20, 40, and 60 year olds). The results revealed that up to age 20, subjects showed an increase in recall rates and that older subjects showed a decline. Lower-order concepts were more often formed than higher-order concepts for all age groups. Age variation in memory performance was partially accounted for by the age variation in concept-forming performance. (ABL)

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Memory development: Sources of the age variation

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Experimental: Memory

Memory development: Sources of the age variation

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Experimentally, the general question is asked whether age differences in memory performance can be accounted for by performance in concept forming. On the basis of a model of structures and processes in complex information processing it is assumed that concept-forming performance determines memory performance in free recall and that concept-forming performance, rather than memory performance, varies with age. N=162 Ss from seven age groups (age range 8-60) were presented with lists of nouns and lists of meaningless syllables, after which they had to solve a task of informational approximation. Using Bentler's structural equation system (EQS) a model was fitted that suggests that (1) performance in concept forming and memory are determined by one factor each, (2) the concept-forming factor determines the memory performance factor, and (3) age is correlated with the concept-forming factor only. In conclusion, it could be asserted that individual differences in concept formation constitute one locus of age differences in memory performance.

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Summary

Experimentally, the question was asked whether memory development in childhood and adulthood can be accounted for by the age variation of cognitive processes other than memory. The results supported the assumption that memory performance in adulthood remains constant, and that the measurable age variation can be explained by problem-solving performance.

1. Background: The CIP-model

The theoretical background of the experiment was constituted by a model of structures and processes in complex information processing (CIP; Hussy, 1983, 1984). This model was developed to cover both structural and processual features of complex information processing. The model also covers processes of memory (see Figure 1).

Insert Figure 1 about here

On the basis of retention time three components of the memory structure are postulated: Very short term, short term, and long term memory. The first of these three components is conceived in accordance with Craik & Lockhart's (1972) dimension of sensory-semantic elaboration. In the short term store, (Atkinson & Shiffrin, 1968) information is gathered and processed sequentially; in the working memory, information can be processed in a time-unrelated way, as well.

Long-term memory is assumed to be constituted by three substructures, namely, the epistemical, the operative, and the evaluative structure. In the epistemical structure, the entire knowledge base of an individual is contained. In the operative structure, functional knowledge is stored. Because there is no clear-cut operator-problem mapping, a third, the evaluative structure is needed to evaluate the potential effectiveness in the selection and in the application of operators to a given problem.

The last component of the CIP-model is constituted by the central processing unit (CPU). This unit is thought of as organizing, monitoring, and controlling all ongoing processes.

By using the CIP-model four phases of problem solving can be distinguished. In the first phase, the CPU controls the definition of the problem and the criteria to be met by gathering information. In the second phase, appropriate operators are selected and applied. The effectiveness of the operator application is tested in the third phase by selecting and applying an evaluator from the evaluative structure. The fourth phase organizes the output, i.e., memory structures are reorganized and responses are made. These four phases are depicted in Figure 2.

Insert Figure 2 about here

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2. The experiment

Method: To measure memory performance Ss were presented with two lists of learning material: The first list consisted of the so-called meaningful material of twenty of either two-, three-, or four-lettered pre- and suffixes; the second list consisted of twenty meaningless CVC-syllables. Each

list was presented three times both acoustically and visually (tape and slides, 2 sec/item). Immediately after each presentation, Ss were asked for free written recall. Recall rates were used as dependent measures.

To measure problem-solving performance two concept-forming tasks had to be solved. In the tasks, sequential informational approximation was required, i.e., Ss had to predict which symbol out of a set of symbols would blink next on a TV-screen. All symbols of the set in use were constantly present on the screen; Ss were provided with immediate feedback on the correctness of their predictions.

To solve the first task, fifth-order concepts were needed, i.e., the relative frequency of the last five items had to be considered. To solve the second task eleventh-order concepts were needed. In task 1, four out of a set of eight symbols were used, in task 2, five out of a set of twelve symbols. The symbols used involved clubs and hearts as in a deck of cards. The sequence of symbols was determined as a stochastic ergodic sequence by a micro processor. Used as a dependent measure was the number of times in which first-, third-, and fifth-order concepts were applied.

In the experiment, Ss were first presented with the memory tasks: Half of the Ss were first presented with the meaningful, the other half with the meaningless material. After dealing with the memory tasks, Ss were presented with the problem-solving tasks. The memory tasks were administered in group sessions, the concept-forming tasks in individual sessions. Each subject spent about two hours with the experimental tasks.

Subjects: N=162 Ss from seven age groups (8, 10, 12, 15, 20, 40, and 60 years old) participated in the experiment. Up to the age of 20 years, Ss were randomly selected from public schools (high schools, universities); to fill up the age groups of 20 years and older, Ss were recruited through advertisements in local newspapers. About half of the Ss in each age group

were females.

Hypotheses: In general, the usual age-differences were expected in both memory performance and concept forming; An increase of both performances up to the (observed) age of 20 and a decline after that age was assumed. This general assumption applies particularly to the recalling of both meaningful and meaningless material and the forming of first-, third-, and fifth-order concepts.

The link between memory and the concept-forming task is provided by the following assumptions. First, it is assumed that in the memory tasks there are more items than could be handled by short term memory. In order to recall a number of syllables that exceeds the Ss's digit span, operators from the operative structure have to be selected, applied, and evaluated with respect to their effectiveness. An example of these operators os concept forming. Generally, it is assumed that Ss who are more effective in applying cognitive operators in the process of encoding and decoding show relatively higher recall scores.

In a similar way, the concept-forming tasks involve memory capacity. First, Ss have to separate from the set of symbols those that are involved in a sequence. Second, Ss have to memorize the order in which symbols follow each other and the conditions of order (depending on the order of concepts needed). These two processes constitute, in part, the basis of correct predictions. However, this does not imply that memory capacity is a precondition of concept forming. Rather, it is assumed that memory and concept forming interact when dealing with the concept-forming task, and that the memory-based identification of higher-order concepts does not take place as long as the concepts needed are not formed.

Developmentally, it is hypothesized, that only concept forming varies with age. The memory structures, in particular, the epistemical structure,

are assumed not to vary with age in adulthood. However, it is also assumed that cognitive operators determine memory performance to a certain extent. For this reason, memory performance varies phenomenologically with age.

Results and Discussion: To test the hypotheses on the age variation of memory performance a 7 (the seven age groups) x 2 (meaningful and meaningless material; repeated measurement) analysis of variance was computed. The significant age effect can be interpreted as supporting the first hypothesis. Up to the age of 20, Ss show an increase in recall rates; older Ss show a decline. There is also a significant ($F = (7,154)=12.301$ $p(F)<\alpha$) main effect that is characterized by a curve that resembles the curve of age differences in memory. The significant main effect of the concept-forming factor ($F = (3,154)=8.776$ $p<\alpha$) shows that lower-order concepts are more often formed than higher-order concepts. This applies to all age groups in the same way (i.e., there is no significant interaction).

To test the main hypothesis--that the age variation of memory performance is determined by the age variation of concept-forming performance--a structural modeling approach was adopted. Using Bentler's (1984) EQS program, a model was fitted that can be described as follows:

(1) There is one concept-forming-performance factor, F1. The indicators of F1 are the relative frequencies with which concepts of the first-, third-, and fifth-order are formed in each task;

(2) There is one memory-performance factor, F2, with recall of both meaningless and meaningful material as indicators;

(3) F2 is uniquely determined by F1;

(4) Age is correlated only with F1.

Insert Figure 3 about here

The last two model features constitute the core of the model. The model fit with the data was good ($\chi^2_{21} = 31.32$; $p(\chi^2) = 0.0685$), supporting the assumption that the age variation in memory performance can--in part--be accounted for by the age variation in concept-forming performance.

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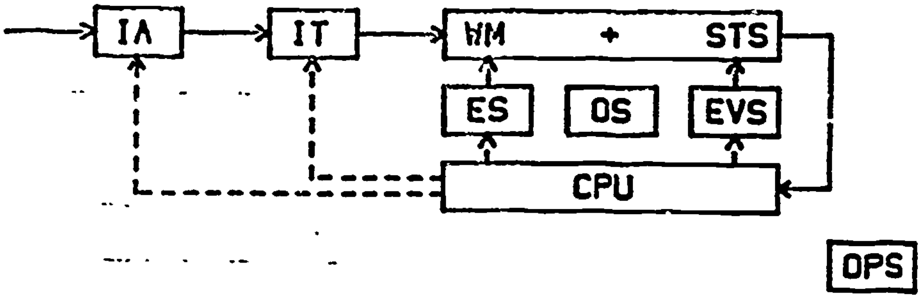
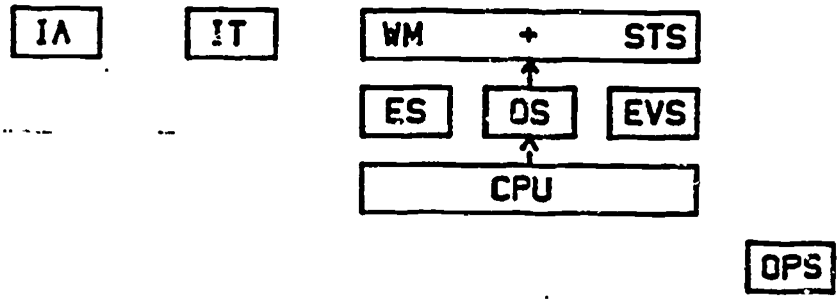
MEMORY STRUCTURE COMPONENTS	RETENTION TIME
INPUT ANALYSIS <IA> INPUT TRACE <IT>	VERY SHORT <0.25 SEC>
SHORT TERM STORE <STS> WORKING MEMORY <WM>	SHORT <UP TO 20 SEC> SHORT TERM MEMORY <STM>
EPISTEMICAL STRUCTURE <ES> OPERATIVE STRUCTURE <OS> EVALUATIVE STRUCTURE <EVS> CENTRAL PROCESSING UNIT <CPU>	VERY LONG <YEARS> LONG TERM MEMORY <LTM>



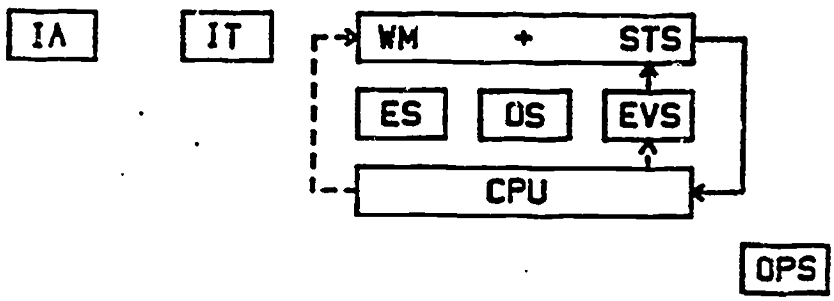
PHASE 1:

DEFINITION OF PROBLEM AND GOAL CRITERIA



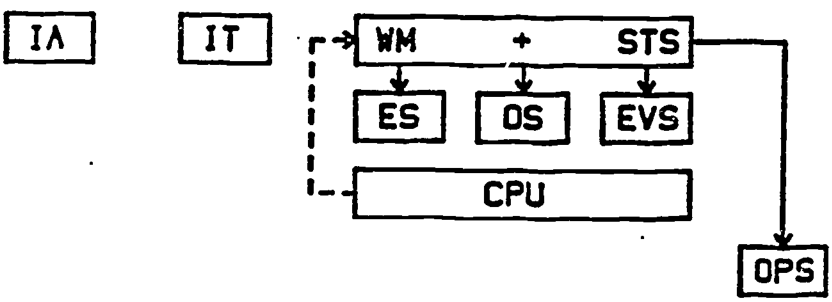
PHASE 2:

SELECTION AND APPLICATION OF OPERATORS



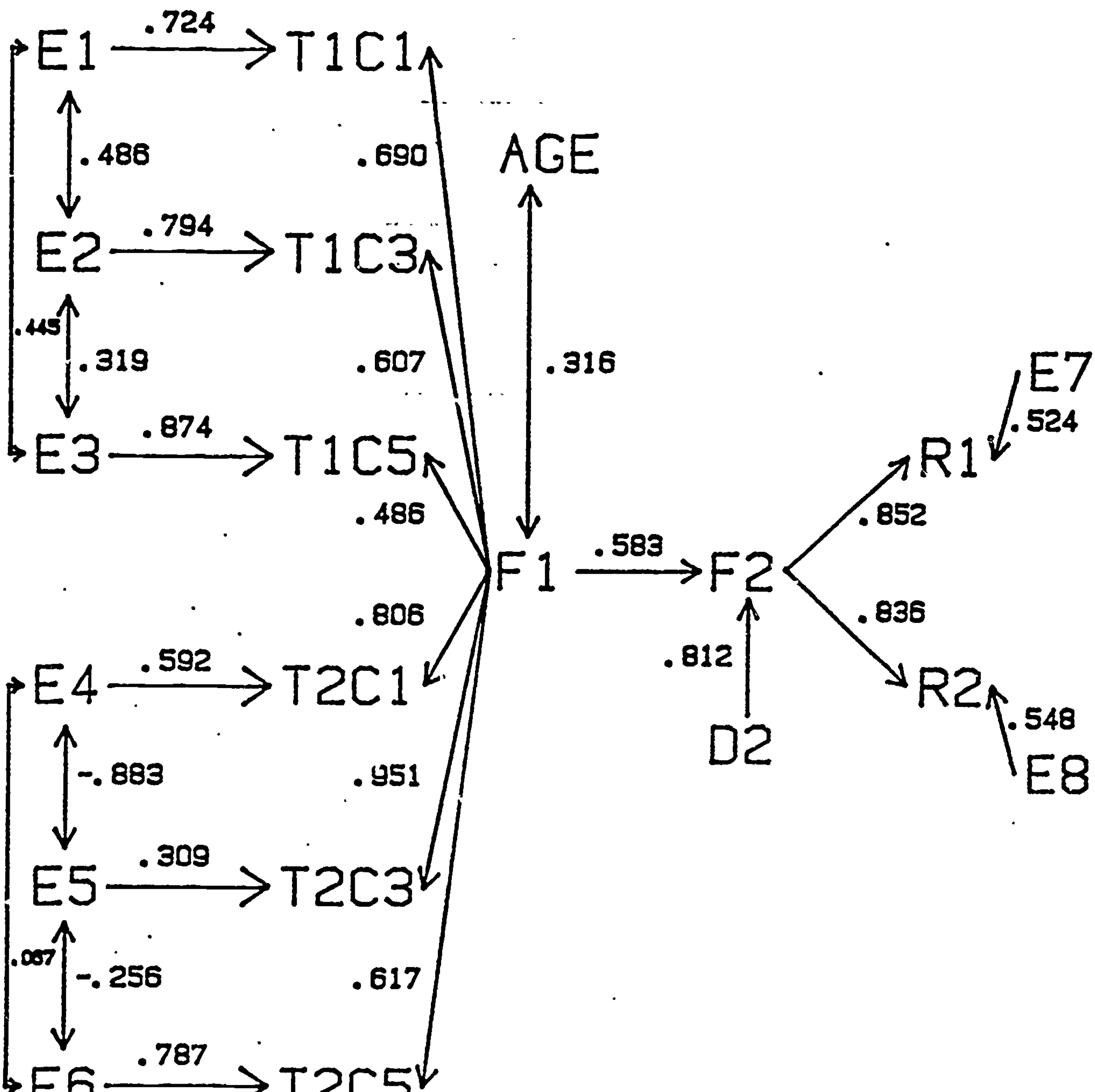
PHASE 3:

SELECTION AND APPLICATION OF EVALUATORS



PHASE 4:

OUTPUT - ORGANIZATION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